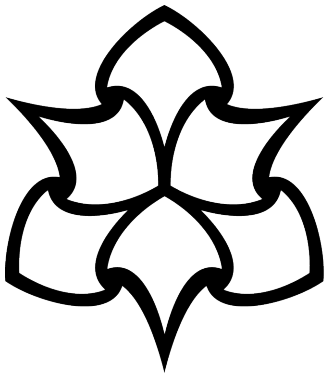

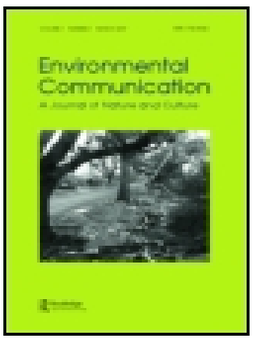

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Towards a Paradigmatic Shift in Sustainability Studies: A Systematic Review of Peer Reviewed Literature and Future Agenda Setting to Consider Environmental (Un)sustainability of Digital Communication

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ABSTRACT

The materiality of digital communication inflicts substantial environmental damage: the extraction of resources needed to produce digital devices; the toxicity of e-waste; and the rapidly increasing energy demands required to sustain data generated by digital communication. This damage, however, is paradoxically under-theorized in scholarship on environmental sustainability. Despite the existing critique of the "techno-fix" approach in sustainability studies, digitization – and digital communication in particular – continue to be celebrated as the tool for environmental sustainability; an approach we coin "digital solutionism." The article presents the first systematic review of the literature to map the implicit assumptions about the relationships between digital communications and environmental sustainability, in order to examine how digital solutionism manifests, and why it persists. We propose a concept matrix that identifies the key blind spots with regards to environmental damages of the digital, and call for a paradigmatic shift in environmental sustainability studies. An agenda for future research is put forward that advocates for the following: (1) a systematic account of material damages of devices, platforms and data systems adopted into sustainability research and practice, resulting in changes in both research framing and methodological foundations; (2) a reconceptualization and denaturalization of the digital itself as a promising solution; (3) a theoretical dialogue between sustainability studies and environmental communication. (4) an expansion of environmental communication as a field, from focusing on the communication aspect of environmental change to include the environmental footprint of communication itself.

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Introduction: the unsustainable digital sustainability

The materiality of digital communication – both the tangible gadgets and the seemingly immaterial "data" – inflicts substantial environmental damage: the ever-growing extraction of resources needed to produce digital devices such as computers and smartphones; the toxicity of e-waste, exacerbated by designed obsolescence of those devices; and the rapidly increasing energy demands required to sustain data generated by digital communication (Chen, 2016; Cubitt, 2016; Gould, 2016). This

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damage, however, is paradoxically under-communicated and under-theorized in mainstream scholarship on environmental sustainability. Despite existing scholarly critique of the "techno-fix" legacy in sustainability studies, including discussions of unintended and unwelcome consequences of some technological solutions, digitization continues to be celebrated as *the* tool for sustainability, environmental and otherwise. Consider, for example, the recent special issue of *Sustainability Science*, published in 2017 and titled "The game-changing potential of digitalization for sustainability: possibilities, perils, and pathways." In the introduction, the issue's editors describe digitization as a key "game changer" in moving towards a more sustainable future: "Digital technologies in the form of e-health services, robotics, or emission reduction solutions could help individuals, organizations, and nations achieve a more sustainable planet in light of the sustainable development goals" (Seele & Lock, 2017, p. 183). Sustainability, they continue, will need to adapt to the developments of the digital age; whereas digitization itself is the "driver that changes sustainability" (Seele & Lock, 2017, pp. 183–4). The rest of the contributors continue in the same spirit. They discuss the promises of digitization in areas such as citizen e-participation in environmental projects (He, Boas, Mol, & Lu, 2017); using digitalization and visualization to understand innovation in water systems (Widener, Gliedt, & Hartman, 2017); sustainable ICT-based education in developing countries (Tabira & Otieno, 2017); Big Data stakeholders as stakeholders of sustainability in the digital age (Lock & Seele, 2017) and knowledge society and digitization (Stuermer, Abu-Tayeh, & Myrach, 2017).

Apart from occasionally noting the negative environmental impacts of digital technologies, only to disregard them as being outweighed by the benefits,[1] we see very little critical consideration of the question of whether, and to what extent, the digital *itself* is environmentally sustainable. Why, despite the overwhelming evidence of its destructive impacts, might sustainability scholarship still hold onto digital communication as a promise of a better, more sustainable future? Is it merely an oversight, or a forced and persistent myopia (or what we shall later call "paradigmatic myopia"), sustained through what Good, in her analysis of media discussions of smartphones and e-waste (2016), coined "symbolic annihilation" – a framing in which digital technologies are glorified while information about their damages is invisibilized?

As this article will demonstrate, the special issue of *Sustainability Science* described above is a symptomatic example of the broader phenomenon: a matrix of blind spots around the damaging materiality of digital communication, which characterizes the field of sustainability studies. The definition of communication that is guiding us here is broad, extending beyond traditionally understood media (print, broadcasting, or digital) in order to do the following: firstly, to include communication of information for the purpose of sustainability projects (for example, when gathering and transmitting environmental data; or when disseminating information or educating about sustainability); and secondly, to consider academic publications on sustainability subjects as a form of environmental communication in itself.

Given the increasing adoption of digital technologies to communicate, analyze and repair environmental damages as well as to set sustainability programs via environmental communication, the coherent critical evaluation of literature on environmental sustainability and digital communication is more urgent than ever. This article presents the first systematic review of such literature, dispersed across different disciplines and guided by multiple and diverse conceptual approaches, in order to map and assess the blind spots regarding the damages of the digital and set the agenda for (changes in) future research. The article concludes with the following propositions: firstly, a call for a paradigmatic shift in environmental sustainability studies, towards accounting for the environmentally unsustainable nature of the very digital tools, brought to provide sustainable solutions. Secondly, an invitation to expand the field of environmental communication from focusing on the communication aspect of environmental change to include the environmental footprint of communication itself.

"To save the planet, click here": solutionism, sustainability and technology

The field of sustainability studies is not unique in its uncritical adoption of digital technologies – a phenomenon we describe here as "digital solutionism," to paraphrase Evgeny Morozov's notion of

"technological solutionism." In his *To Save Everything, Click Here* (2013), Morozov details how digital technologies such as the Internet, Apps, tracking devices etc., are imagined as being both uniquely suited and unquestionably necessary tools for solving political, economic, and environmental problems; while their dangers – to individual freedom, political democracy, or indeed the environment – are rarely acknowledged. Apart from the genealogy of solutionism as a philosophical framework, detailed by Morozov, one should also note here the logic of commodity fetishism (Marx, 1867/1990), where objects are seen as possessing positive values and satisfying a "need" (real, or, often times, orchestrated by consumer culture), all the while being "magically" detached from the labor process and the material impacts of their production, whether human or environmental. Such a logic might explain why digital tools are still perceived as a solution to, rather than cause of, environmental woes.[2] Nevertheless, in a field specifically dedicated to the environment, one may expect a more critical approach to technology that has a tremendous – and continuously increasing – environmental footprint. In order to better understand the tenacious embrace of the digital where one would expect skepticism or even rejection, we need to foreground our discussion with a brief overview of sustainability studies and its view of technological solutions.

Since Gro Harlem Brundtland set out her vision of sustainable development in the Brundtland Report (WCED, 1987), the central role of technology in driving environmentally benign, socially just, economic growth has been a core tenet of sustainability discourse, underpinned by the conviction that poverty, global inequality and environmental degradation are linked, and that to address one, it is necessary to address all. Of particular note for our work is the prominent role assigned to ICT in achieving these aims:

> Information technology based chiefly on advances in micro-electronics and computer science is of particular importance. Coupled with rapidly advancing means of communication, it can help improve the productivity, energy and resource efficiency, and organizational structure of industry. (WCED, 1987, p. 217)

While the report notes the potential for harm in the unconsidered use of technology, the fundamental message is one of optimism in the potential for technological progress to mitigate the environmental damage caused by economic growth. This optimism is shared by sustainable development's "sister" discourse, "ecological modernization" theory. Lacking the environmental justice element of sustainable development, ecological modernization theory focuses on the reconfiguration of the capitalist political economy of developed nations, arguing that with government support and appropriate technological intervention it is possible for economic growth to benefit the environment (Dryzek, 2013). Within the sustainability field, the rhetorics of eco-modernization and its techno-fix approach have received considerable criticism, for their unquestioning acceptance of the growth paradigm (Grunwald, 2016); for their anthropocentrism (Crist, 2016); and for misunderstanding the causes of the modern environmental crisis, disregarding technology's ambivalent record in mitigating the environmental consequences of economic growth, and its tendency to cause unintended and unexpected environmental consequences (Dietz & O'Neill, 2013).

Nonetheless, despite limited empirical evidence that technological development can solve the present environmental crisis (Næss & Høyer, 2009; York, Rosa, & Dietz, 2003), the pragmatic and technocratic character of these discourses remains attractive to policy makers, providing as they do, an alternative to the environmental movement's traditional position that a transformation of the core political and economic institutions of modern society is required to achieve long-term sustainability (Mol & Spaargaren, 2000). The assumed critical role for technological innovation, including digital innovation, in achieving an economically, socially and environmentally sustainable future, has come to underpin much of modern sustainability policy, at national and transnational levels (OECD, 2009; United Nations, 2012).

Our article is informed by, and builds on, the considerable critical voices regarding technological solutionism in sustainability research, in an attempt to map and understand the persistent and uncritical embrace of digital technologies, occurring *despite* those critical voices. Using digital solutionism as a perspective and an assessment framework, we ask: How are digital technologies imagined as

being in the service of environmental sustainability? How and when do discussions of digital technologies follow the logic of the "techno-fix" approach? And lastly, how does digital solutionism shape the matrix of blind spots regarding environmental damages of the digital?

Methodology

Systematic review

In order to address those questions beyond specific cases (such as the special issue of *Sustainability Science*, or the many other discrete examples we came across but which may be considered anecdotal), we adopted the "systematic review" methodology. In a systematic review a large selection of existing academic work is collected from across several databases, using a defined search strategy, in order to assess developments and concepts in scholarship around a particular topic; evaluate changing trends in publication patterns; or analyze the state of a particular field – including gaps or problems – and set up an agenda for future research accordingly. A systematic review can draw on statistical analysis ("meta-analysis") of quantifiable information about academic publications; or engage in qualitative analysis, examining content and identifying themes or current areas of knowledge (Petticrew & Roberts, 2008). In our case, we used the latter approach, carrying out a qualitative analysis of our corpus through several consecutive stages of thematic mapping.

Among the many academic works that used systematic reviews, a few are worth noting here that were of particular inspiration. For example, a systematic review of on-line information seeking behavior in health (Sbaffi & Rowley, 2017) established a typology of ways in which trust and credibility were conceptualized across academic publications. In a similar vein, Our systematic review created a map of the different ways the digital was conceptualized as an aid of environmental sustainability. Another example is a study where a systematic review of literature on the relations between organizations and marketing agencies (Keegan, Rowley, & Tonge, 2017) was used to develop a conceptual matrix for an empirical phenomenon, scattered across disciplines and guided by multiple perspectives. Similarly, our review traced and analyzed the relationship between environmental sustainability and the digital across disciplines for our integrated conceptualization of "digital solutionism" and "matrix of blind spots"/"paradigmatic myopia"). And finally, our proposed contribution to the field of environmental communication is informed by the systematic review of peer reviewed articles in this field (Comfort & Park, 2018) which outlined key trends and pivotal shifts in its research agenda. As discussed in the conclusion, our own article points towards one such potential shift.

Search and inclusion criteria

To obtain our corpus, we conducted systematic searches of four electronic databases, two with a science and social science focus – Thompson's Web of Science and Scopus, and two with a business focus – ABI and ESBCO Business Source Premier. A flowchart of our search process in provided in Appendix 1 (see supplementary material). We began by examining the intersection of "digital" and "sustainability." Initial key word searches identified over 6000 records, confirming the extent to which the two concepts have become entwined. Restricting our criteria to publications from the last 10 years and "environmental" sustainability reduced this number to a little over 1100. Confronted with a dataset too large for close reading and too diffused for our research questions, we rethought our strategy.

Our next step was to specify both "sustainability" and the "digital," being fully aware that such specification it itself would likely affect the kind of narratives we would find. Based on our knowledge of sustainability research, on one hand, and of digital media studies, on the other, we devised a more specific, and thus more restrictive, set of key words. Instead of "sustainability" we used derivatives of the following: "sustainable production," "sustainable consumption," "sustainable waste

management," "e-waste," "sustainable community," "education for sustainability," "sustainable future," and "sustainable IT." Instead of "digital" we used "digital or online," "Apps or mobile technologies or smartphone" and "virtual." Searching within title, abstract and keywords identified 326 unique records published in English between 2008 and 2017. A list of our search term combinations and results is provided in Appendix 2 (see supplementary material).

The abstracts were screened by both authors to determine eligibility for our study. Three inclusion criteria guided our analysis:

(1) The digital should form an object of study and not solely a methodological tool or a data repository;
(2) Sustainability should have an environmental focus rather than relate to more general concepts such as disaster recovery or future business profitability;
(3) The study should be an academic journal article rather than an opinion piece.

These criteria excluded 196 articles, yielding 130 records for full text evaluation. Three articles could not be obtained, and a further 49 were excluded after reading, following the same exclusion criteria. The remaining 78 articles formed the corpus of our study. A full list of our texts is provided in Appendix 3 (see supplementary material).

Findings: sustainability and the digital

Initially, we mapped our corpus with three questions in mind: how the authors saw sustainability; how they saw the digital; and how they saw the two fields intersecting, noting already at that stage that digital solutionism was prevailing (albeit with nuances). At the next stage, we mapped more closely, through an inductive process of reading and discussion, the specific ways in which digital communication and sustainability were conceptualized together. Here we have identified three broad categories: digital as a tool of sustainable innovation; digital as a facilitator of change in people's behavior (with two subcategories – education or changes to consumption patterns); and digital as a material object. Each article of our corpus was assigned to these categories, with ten articles spanning more than one category (see Figure 1) the most overlap occurring between "consumption" and "tools." At the final stage, we engaged in close reading of articles by category,

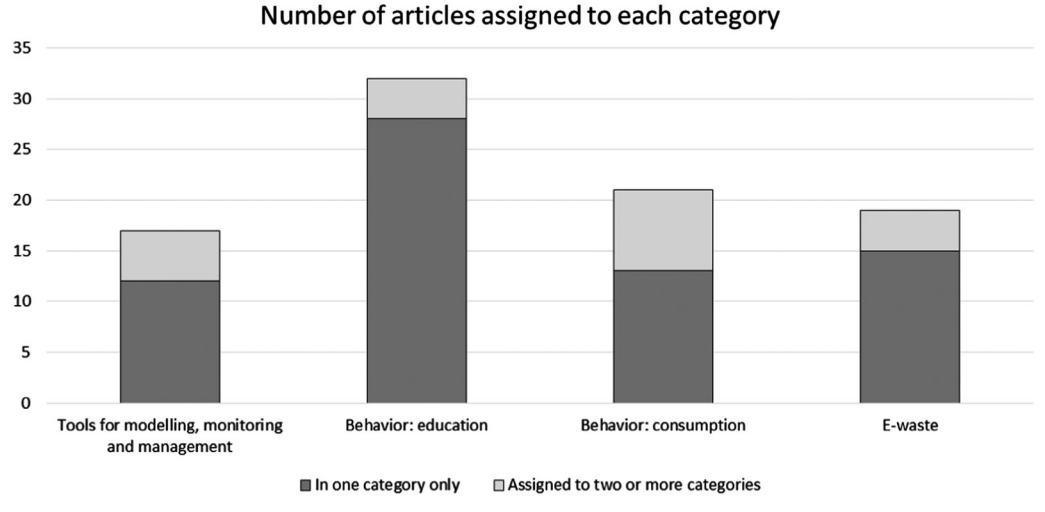

Figure 1. Number of articles assigned to each category.

in order to create a detailed mapping of themes and approaches within each. The results are presented below.

The digital as a tool: management, modeling, monitoring

The first way in which digital technologies figured in our corpus was both most celebrated and most instrumental, approaching the digital as a tool to aid sustainable processes in ways that are innovative and efficient. The 17 articles in this section addressed three types of such "tools." Firstly, there were tools of resource management: smart technologies that aid energy consumption and management [1, 2];[3] eco-efficiency of energy consumption and cloud computing [3, 4]; urban management of consumption and conservation of water [5] or the management of waste and recycling [6, 7]. These and similar articles approach the digital within the framework of efficiency and eco-efficiency; fully acknowledging the need for sustainable management of resources, they put forward various digital tools as ultimate solutions for more environmentally sustainable processes, envisioned at a local (city), national, or global level. Among the articles that approach digital technologies as efficient tools, some are explicit and vocal about the environmental damages of the digital, be that the growth in greenhouse gas emissions as a result of data-generating activities such as social media, streaming or file-sharing [4]; or the energy demands of the "always-on" culture, supported by the Internet and online services [8]. These very articles also envision digital technologies as part of the solution: from developing environmentally sustainable Cloud Computer Centers [4], to ICTs as tools to monitor and control operation systems and reduce energy use [8].

The second way of approaching digital tools, in the similar vein of ecological efficiency, is the notion of digital modeling. For example, in an article about virtual apparel [9] a system of digital 3D design is promoted as a tool for sustainable consumption that minimizes the use and disposal of actual materials, and has a potential to create individually modeled clothes that are more valued and are therefore unlikely to be disposed of so quickly. In a similar vein, Matsuda and Kimura [10] put forward the notion of a "digital eco-factory" where much of the production process is modeled, tested and evaluated digitally, promoting a more sustainable production process; Ketter, Peters, Collins, & Gupta [11] develop a platform to model sustainable electricity consumption; and Frostell, Sinha, Assefa, & Olsson [12] propose a platform to model "household metabolism" (purchases, transport, energy use in the home, leisure activities of a household, and more) and its carbon footprint. Digital modeling is also discussed in the context of building and construction [13, 14] and urban water systems [5] – in all these cases, virtual simulation, models and data analytics are presented as means of more precise design and production, often without requiring physical resources. Digital modeling is also addressed a tool of post-production management, as well as detection, evaluation and continuous adjustment of use, all in the service of sustainable resource use (energy, heating, water, reduction of waste). On a more tentative note, Ali and Frew [15] argue that digital technologies, if adopted by tourist management, could be used to calculate environmental damage of particular tourist practices or create virtual tourist experiences that would be more environmentally friendly.

The last way of addressing digital tools which we discuss in this section is monitoring. Already mentioned in the final section of Loveday et al. [8] – among the earliest articles in our corpus – as a hopeful look into the future and "the new opportunities afforded by information technology" (p. 4643), digital monitoring emerges in most recent publications as one of the key environmental potentials of the digital. Monitoring was frequently tied to virtual modeling in some of the articles mentioned above, but also discussed by several authors as a separate process. In those articles, the monitoring tasks themselves varied – from real-time evaluation of environmental conditions in ports [16] to mapping forestry, fishery, water, carbon, land ownership, or reports of environmental damages [17]. The main potential of the digital, here, is the precision of measurement, the reliability and the scale of information which, in turn, allows more precise analysis. The argument put forward by Gale, Ascui, & Lovell [17] is particularly interesting here, when they discuss the transformative

potential of the digital for sustainability auditing: "ICT-induced disintermediation" allows direct flows of data that are not only precise but also transparent and impartial. Coupled with on-line platforms for "citizen science" (unmediated reporting from below) and with publically available databases on environmental sustainability, ICT and Big Data, they argue, will bring "new truths" and democratize environmental governance as a whole.[4]

The articles in this section demonstrate that digital solutionism is not only a part and parcel of the eco-efficiency approach, but that it is continuously on the rise, with the spread of Big Data and the many tools that generate it. While some authors are acutely aware of the environmental tolls of computing and digital communication, the solutions they seek seem to be firmly embedded, again, in the current or future potentials of the digital itself, which only needs to be used correctly, finessed or adjusted, or further developed.

The digital as facilitator of changing behaviors 1: education for sustainability

In all the materials examined for this project, the "education for sustainability" section was the largest – 32 of our 78 articles incorporated this element. Their educational focus varied from schoolchildren, to university and college students, to officials dealing with the environment, to other professionals such as engineers and designers. Some of the articles focused on very particular topics relating to the environment and "sustainability education," such as learning about trees or plants, or about conservation, or about environmental impacts of particular consumption practices, while others approached sustainability more generally, as a societal need for change. Sustainability itself was often described as a complex concern, yet at the same time, was taken as a given by most of the authors. "Education for sustainability," in other words, was often a normative position, rather than a problem that can have different conceptualization (as we will demonstrate in the "consumption" and "e-waste" sections below).

When it comes to digital technologies and their role in education for sustainability, almost all of the articles in this selection demonstrate a positive, if not celebratory, approach. Several of the authors focused specifically on mobile digital devices as new pedagogical tools, portable, personalized and engaging [18, 19]. As such, the devices were explored as having potential to transform the space of the classroom and allowing "new" ways of connecting to the environment which may be outside of the traditional school space or time, empowering in their access to different forms of knowledge and experience, and allowing location-based learning [19–22]. Electronic devices were also considered potentially more environmentally friendly than textbooks, which, if adopted by many students, would have the ability to create a "greener campus" [23].

The remainder of the articles focused on on-line environments and digital platforms themselves, rather than on devices that access those platforms. In some cases, the focus was specifically on the possibilities of collaboration and knowledge sharing – whether between learners [24] or between industry executives, service providers, businesses, researchers and environmental advocates [25]. In those and other articles, the emphasis was often also on the community-building potential of the Internet and social media with regards to possible changes the digitally mediated education for sustainability can bring [21, 26–29] Here, the assumption (common in much of the literature on citizens' digital engagement in various social and political domains) is that citizen on-line participation is somehow "unmediated," that is, not dictated by political bodies and institutional forces. As such, it is seen as being more empowering, whether for social movements, community building, or in our case, for bringing environmental social change via consciousness raising or via citizens demanding changes to policy.

In other cases – and these were the majority of the articles in our study – on-line environments were presented as particularly suitable for teaching and learning about sustainability. Some of the articles, for example, examined the potential of virtual environments as gamified pedagogical tools, whether as a virtual museum created in *Second Life* to teach about conservation [30]; an on-line simulation used to train officials involved in flood risk management [31]; or a broader notion

of gamified learning for environmental awareness [11, 32, 33]. Others focused on digital tools that allow active engagement with sustainability-related topics via self-directed, creative learning [34, 35] and collaborative and/or critical thinking [21, 36–40] with regards to both the environment and the learning process itself. Yet others described ways in which on-line platforms can be used in teaching via testing one's knowledge, for example, by using an "on-line sustainability literacy test" [41] or an "Ecological Footprint Calculator" [42]. And lastly, some articles merely noted the need for sustainable development to be incorporated into the curricula – interestingly, that need was particularly flagged in relation to engineering students [43–46] – and that incorporation seen to be frequently done in on-line or in blended (on-line and on-site) environments.

The articles discussed in this section range in their approach to education, from looking at the learners, to addressing the subject, to analyzing the learning process itself. In the majority of the articles, the focus was on new skills, attitudes or knowledge, with only some authors discussing the link between those and broader social changes. But what is most striking is that while the articles offer a complex overview of what a "sustainable future" we educate towards might look like, all but one advocate for the use of digital tools in education for sustainability, without examining the negative environmental impact of such tools.[5] One exception is an article raising awareness of potential e-waste that would result from introducing digital devices, as stated by Selby, Carter, & Gage [23]. In their discussion of shifting towards e-textbooks to make a greener university campus, they note: "if the introduction of more e-devices to read e-textbooks is to have an environmental benefit for the entire campus, improving student awareness of e-waste disposal is very important" [23, p. 154]. However, such awareness does not challenge the move to introduce digital devices on campus; rather, it merely aims to safeguard its implementation. It is both telling and troubling, that only *one* article in this part of our corpus brings up the environmental costs of digital innovation in education in the form of energy, mineral extraction and landfill – but even there, it is not the reduction of digital technologies, but merely their critical and competent use, that is suggested [29, p. 153] – gesturing, in turn, to the importance of education for sustainability, rather than to its problematic self-affirming logic.

The digital as facilitator of changing behaviors 2: sustainable consumption

The tendency towards digital solutionism, which was overwhelmingly present in articles on education for sustainability, was also common in the "consumption" pool of our data, albeit the latter demonstrated a broader range of positions towards the digital, as well as towards sustainability itself. The 21 articles analyzed under this rubric present two main ways of thinking about sustainable consumption. The first focuses on the consumers and their behavior. Some authors look at the relations between consumers and products, in order to establish how the different types of relationship to what one buys can shape more sustainable practices such as buying less, or keeping products for longer [9, 47]. Others explore consumer awareness of how environmentally friendly – or damaging – their purchases are. Nghiem and Carrasco [48] for example, discuss a "sustainability App" that calculates the impact of products on biodiversity; and Frostell et al. [12] present a web-based "footprint calculator" of "household metabolism." Sustainable consumption, here, rests on the assumption that a higher awareness of the environmental issues associated with concrete products will lead to a change of behavior; for example, that availability of information on how "green" a product is will shift consumer behavior towards "greener" consumption practices [49]. In most cases, the products themselves were merely assumed to be more – or less – environmentally damaging, and the focus of the discussion was not their actual production process but on the information (and in some cases, the branding) which presented them as environmentally friendly [50] – regardless of their actual environmental credentials.

The second approach to sustainable consumption that emerged from our corpus concentrates on the products and on part or all of their life cycle: manufacturing, delivery, selling and re-selling, and disposal or recycling. Here we see a more focused discussion of potential environmental hazards of

the production/consumption cycle. Some articles, for example, address carbon emissions [9, 10, 51] while others tackle product disposability and ways to minimize it – for example, by promoting second-hand or shared consumption [52–54]. Sustainable consumption, here, is imagined as a practice to reduce carbon footprint, and/or redirect products away from landfill. The authors show a range of position with regards to the achievability of such aims; some point to contradictions where, for example, the retail of second hand clothes may direct them away from landfill but simultaneously increase emissions due to transportation [51].

Where it comes to the digital itself, authors' positions vary. In many discussions, the digital is treated instrumentally, as merely a facilitator of particular consumer behaviors. This is usually the case with articles focusing on on-line platforms, such as those for trading new and/or second hand goods; or sites that allow collaborative consumption (swapping, rental or resale) [51, 52]. Similarly, articles that explore changes in consumer behavior as a result of greater awareness, treat on-line environments or mobile and social media platforms as instrumental communication or collaboration tools, or as neutral depositories of information about alternative consumer practices [55], products [49], recycling [6], or even as effective sites of business and marketing communications that promote sustainable industrial practices [25] or corporate sustainability [56]. The latter, interestingly, seem to focus on the marketing efforts themselves rather than on actual sustainability concerns; as such, the article by Lee [56] resonates with Saari, Baumgartner, & Mäkinen [50] who discuss ways of promoting smartphone brands as being more environmentally friendly.

Other articles take a more nuanced approach, questioning the link between on-line consumption and sustainability. For example, while several authors agree that sites for second hand and shared consumption will necessarily make a positive environmental impact because they connect more people together and allow them to reuse and share products instead of disposing them, others take a more critical stand. Some point out that e-commerce, by the nature of its broad geographical spread, might increase energy demands and emissions from the required shipping [51, 57]; such negative environmental impacts, as Clausen, Blättel-Mink, Erdmann, & Henseling [57] argue, need to be calculated into the positive approach to the potential of e-trade. Others note that buying environmentally friendly or Fairtrade products online might have a negative effect on the sense of activist community. Lekakis [58] for instance, states "[d]igital media have indeed spread the fair trade word. Still, digital political engagement with ethical consumption is not mobilizing, interactive, or sustained" Lekakis [58, p. 171]. Yet others argue that despite the positive potential of second hand on-line consumption, the nature of on-line shopping might paradoxically cause an increase in "self-indulging," "impulsive" buying, excessive because it is guilt-free due to buying second-hand rather than new products [59].

The articles reviewed in this section demonstrate that there is no univocal model of future solutions about sustainable consumption and the digital – unlike the articles on education for sustainability, the studies discussed in this section demonstrate a broader diversity of positions, including critical and detailed evaluations of the environmental pros and cons of various digital tools and platforms. Tellingly, however, *none* of the articles advocate abandoning digital tools. Instead, their view of the digital can be mapped onto a continuum ranging from full adoption of digital tools in the future, such as the case of virtual production or discussions of on-line shopping [49]; to a tentative adoption that requires more data and more nuanced analysis of consumer behaviors; to an invitation to pay a closer attention to non-digital factors (such as changes in values and attitudes and other psycho-social barriers); to a call for regulating, optimizing or otherwise managing the digital – whether by governments, or citizens – in order to balance the advantages and environmental harms of the tools and platforms.

The digital as a material object: e-waste

The final section of our corpus considers the issue of the e-waste produced once digital devices are discarded. By the nature of their subject matter, these 19 articles focus specifically on the materiality

of the digital and its associated environmental impacts, in contrast to the preceding sections. Following Pickren [60], we note the dual and context-specific character of e-waste apparent within our corpus, evident in two ways. First, in how e-waste is conceptualized: both as a resource, a source of valuable materials and opportunities for employment in the facilities where it ends its life, but also as a hazard to health and ecosystems; and second, in the socially constructed manner in which an object comes to be classified as "waste" – a decision influenced as much by accelerating technology cycles and ravenous consumer demand as the functional performance of the device. The small size of digital devices contribute to this perception of insubstantiality and transience, making them easy to discard without reflection.

Our corpus takes two approaches to the issue of e-waste. The first set, predominantly dated from the first half of our chosen date range focuses upon the fate of the device once it is discarded, and often shipped to developing countries sometimes via illegal routes. A series of case studies [61–64] provide a critique of the "bridging the digital divide" narrative made explicit in the G8 "Okinawa Charter on Global Information Society" (2000), which accords ICT the role of enabler of future democracy, prosperity and development. Instead, as the articles reveal, programs to provide low cost ICT equipment to developing countries, became a pretext for developed countries to avoid responsibility for the consequences of their overconsumption by dumping low quality devices on poorer nations. Sustainability in these articles is framed as both an environmental justice issue and in terms of the local harm caused by the global flows of e-waste, in particular through the hazardous substances released during processing to recover economically valuable materials. As Oteng-Ababio [63] notes, possessing limited capacity to mitigate the hazards, and few alternatives sources of income, members of recipient communities face a stark choice: "challenged to choose between 'poverty and poison'; between working in recycling facilities and being exposed to health hazards and making a living on the one hand, or remaining unemployed on the other" (p. 203).

It is not therefore, the device itself which is characterized as unsustainable. The potential for the international trade in second-hand devices to support socio-economic development, and for the recycling of these devices to conserve resources and provide employment, remains uncontested within our corpus. Rather, it is the unregulated recycling of devices, undertaken without appropriate controls, which is presented as causing harm, and the manufacturers and governments who turn a blind eye to the issue, who bear responsibility for the consequent human and environmental damage. The proposed solutions therefore, are addressed to these actors. Nnorom and Osibanjo [65] favor a governance-based approach, arguing appropriate legislation, implementation of Extended Producer Responsibility and technology transfer are required to support more sustainable recycling practices within recipient countries, while Cumps [66] argues for e-waste management solutions to form an integral part of the operating model for organizations which export digital devices to development projects in the global South.

The second set of articles reveal a shift in focus, from e-waste dumping to interventions to reduce the environmental impact of digital devices within the countries, which generate the waste. As mobile phones, in particular, become ubiquitous over the time-frame of our study, e-waste can no longer be conceptualized as an issue solely generated in the global North and we see a corresponding shift in the geographical focus of those studies. Some take a global approach, thus Ciocoiu, Hincu, & Dobrea [67] assess the factors which influence generation of e-waste in different country contexts; Szamałek and Galos [68] make an economic argument for operator take-back schemes through an estimate of the waste metals accumulated in spent mobile phones; Charles, Douglas, Hallin, Matthews, & Liversage [69] assess the precious metal content of printed circuit boards; and Son, Lee, & Lim [70] consider whether technology convergence will decrease the environmental impacts of digital devices. The majority of our corpus however, focus on county-specific interventions to prevent or divert digital devices entering the waste steam. Improved recycling is one approach [71–73], alongside improved product design to assist recycling [74]. Other articles consider alternative interventions, such as the potential for refurbishment and repurposing to provide improved environmental outcomes over recycling [75, 76]; or software solutions which allow the continued use of outdated hardware [77].

Finally, Okewu, Misra, Maskeliūnas, Damaševičius, & Fernandez-San [78] provide a link between the e-waste literature and the education literature, outlining the use of a SharePoint site to improve the environmental awareness of computer users and reduce waste.

Throughout these articles, understandings of sustainability are underpinned by the Brundtland (WCED, 1987) formula of achieving environmental and social benefit through the mechanism of sustainable growth. Often, we saw the implicit assumption that improved functioning of the market, through the provision of information and appropriate infrastructure, was all that was necessary to provide sustainable outcomes. And here we see a further, striking, example of the dual and paradoxical nature of the digital, apparent throughout our corpus. In its e-waste form, the digital is characterized as unsustainable due to the potential for resource loss, and the environmental and social harms which its processing and disposal entails. The digital in its functional form however, is presented as a solution to unsustainability, providing the means through which consumers can be educated. As Okewu *et al*. [78] state, echoing so many digital solutionist narratives we saw elsewhere: "ICT could be instrumental to solving the problem e-waste and energy conservation management through sustained online real-time green computing conversations and education" (p. 1869). It is not accidental that a "good" use of the digital – one that would make it a solution for sustainability concerns – is contingent not only on a more environmentally friendly computing, but also on education. But just as in the education corpus, the question of whether, and how, education might lead to sustainable behavior remained unaddressed, and we saw no examination of the potential for conflict inherent in positioning both the digital and market forces, which create the issue of e-waste, as also providing the solution. The logic of digital solutionism therefore, is present in the e-waste literature, even as this literature is acutely aware of the harmful materiality of digital devices at the end of their life.

Discussion: paradoxes and myopias of digital sustainability

Our systematic review of academic peer reviewed literature on sustainability and the digital allowed us to create a thorough and detailed mapping of the many ways in which digital technologies are currently conceptualized and presented. In all the articles in our corpus, digital communication was described as being in service of sustainability projects – from tools of sustainable innovation that manage and communicate information about the environment; to communication technologies tasked to change consumer and citizen behavior; to communication devices as material objects at the end of their life. The literature we reviewed displayed a range of approaches to the digital, from blindly hopeful, to extremely sophisticated, critical and, at times, skeptical. Yet even when warning against the environmental costs of manufacturing and operating digital devices, platforms and environments; or when cautioning against the unintended effects of efforts to change people's behavior; or when describing how the devices' improper use or disposal resulted in toxic e-waste, none of the articles in our corpus advocated for reducing – not to mention refusing – digital solutions altogether. If dangers or concerns about the environmental damages of digital communication were outlined, this only led to suggestions about *how to do it better* – more precise tools, further research, critical thinking, better education. In that respect, the literature analyzed here does not merely demonstrate specific blind spots around *particular* environmental harms of *particular* forms of digital communication – as those particularities were, in some cases, noted and addressed. Rather, it demonstrates a matrix of blind spots (even if one was accounted for, others were ignored), better characterized as a *paradigmatic myopia*.

Such myopia, manifesting in the staggering prevalence of digital solutionism across the board, can be seen as a continuation of the legacy of "techno-fix" approaches within sustainability studies, persistent despite the existing scholarly critique, which we briefly outlined at the start of the article. That this legacy persists is supported by the overall belief seen throughout our corpus in the power of technology and technological progress, where every new invention carries a promise of "doing better,"[6] remaining stubbornly blind to both the failures of older technologies (Good, 2016; Maffey, Homans,

Banks, & Arts, 2015), *and* to the damages inflicted by new ones (Chen, 2016; Cubitt, 2016; Good, 2016).

The myopia around digital harms, built into digital solutionism, also needs to be understood as simultaneously engrained in the power of the global digital economy (Chen, 2016; Fuchs, 2015; Qiu, 2017) *and* in cultural beliefs and media practices that accompany and sustain it. As several scholars note, the digital economy rests on "planned obsolescence" (Chen, 2016; Gould, 2016) of digital devices, purposefully designed to have a short life span and be replaced frequently. In addition to its economic hold (where, for example, repair is always more costly than upgrade/disposal), planned obsolescence is supported by consumer trends, cultures of communication, and by what Good (2016) has poignantly called "symbolic annihilation." In her detailed analysis of media representations of iPhones, she noted the iconic formation of the iPhone as a seamless dream, co-constituted through a consistent erasure of the stories of e-waste and other environmental damages, which the technology generates. Furthermore, as critical media and communication scholars remind us, the culture of digital economy rests on a deliberate and consistent decoupling of "digital labor" (seen as immaterial, "virtual," data-based) from environmental degradation, even though the two are deeply intertwined (Casemajor, 2015; Fuchs, 2008). Within this logic, as Fuchs (2008) notes, environmental problems continue to be seen as technological, rather than social, perpetuating the myth of a "sustainable information society" – and, as we shall add, the myth of the digital as a "game changing" savior of sustainability hopes.

The role of media and communication scholarship is crucial here, both as a culprit and a hope for change – and this is where, as we state in the conclusion, environmental communication as a field can take a lead. We suggest that myopic thinking around ecological harms of digital technologies, prevalent in our corpus, cannot be understood within the framework of sustainably studies alone. Rather, it is also caused by a long-term blindness within the field of communication and digital/cyber/Internet cultures. Recent critical interventions notwithstanding, this field, especially in its English-language, white and Western-centered mainstream, does not tend to examine digital communication's complicity in environmental degradation, nor does it tend to account for the materiality of the digital, when discussing culture and communication (unless the latter is specifically focused on the environment). Historically, Internet/cybercultures studies, for example, have envisioned digital communication as primarily and almost exclusively "virtual": as a "new frontier" detached from the territoriality of "land," the physicality of "flesh" and the materiality of the "metal" (Escobar et al., 1994; Fernback, 1999; Turkle, 1995). Despite decades of critical voices from feminist, postcolonial, diasporic and "global South" scholars (Aristarkhova, 2005; Gajjala & Gajjala, 2008; Nakamura, 2000; Oguibe, 1996; Oguibe & Hoeller, 1996/2001; Sandoval, 2000), mainstream digital communication studies have enjoyed – and continue to enjoy! – the luxury of ignoring the deeply material consequences of the digital since such consequences mostly impact those in the global South and the disenfranchised, racialized and colonized communities in the global North (Chen, 2016; Cubitt, 2016).

As Chen rightfully notes in his discussion on the "material blind spot" in ICT research (see also Fuchs, 2015 and Gates, 2013), the environmental toxicity of ICTs as both a result and a cause of global social and ecological injustice remains "radically under-theorized" (2016, p. 122), due to the trends in global political economy where "immaterial" labor has grown radically; giving rise to the discourse of the "digital sublime." In the meantime, Chen argues, the disciplinary prevalence of semiotic analysis within communication and media studies "further distracts us from the mounting material labor and environmental problems involved in sustaining the ever-expanding cyberspace" (2016, p. 125).

Reading our corpus vis-à-vis legacies of digital solutionism in sustainability *and* in media and communication studies, it becomes apparent that both fields share a paradigmatic myopia, one that is supported by the digital economy and culture, on the one hand, and by normative disciplinary canons, on the other. Furthermore, what our corpus reveals is the dangerous power of digital solutionism when the two forced myopias meet, feeding and supporting each other. On the one hand, the

immaterial bias of communication studies might be informing uncritical visions of the digital by sustainability specialists. On the other hand, the techno-optimism of sustainable development discourses might be feeding the dreams of digital media's immateriality. It might be that the symbolic annihilation of stories of digital footprint in the media is what causes educators and policy makers to carry on seeking transformative solutions in the newest digital gadgets and platforms, while continuing to disregard their impact on the environment. And crucially, we must thus challenge the symbolic annihilation in authoritative academic fields, such as the ones reviewed in this article.

Abolishing digital solutionism: conclusion and agenda setting

The analysis presented here aims to be the first step in future agenda setting, in both the field of sustainability studies and that of environmental communication. First and foremost, we call for a paradigmatic shift in the field of sustainability studies, from digital solutionism to critical accountability. More specifically, we propose the following:

(1) A systematic account of global and local material damages of devices, platforms and data systems adopted into sustainability research and practice, resulting in changes in both research framing (where environmental harms of digital solutions would be a starting point of any investigation, rather than an afterthought) and subsequent methodological foundations and empirical foci.
(2) A reconceptualization and denaturalization of the digital itself as a default solution. Such denaturalization would require a stronger integration of critical voices within and about sustainability studies – from perspective on techno solutionism, outlined at the start of the article, to critiques of the discourse of sustainability itself. In doing so, sustainability studies should develop a more accountable perspective on the global complexity of potential perils and harms of some sustainability agendas. And it will also require a transdisciplinary dialogue with other fields, first and foremost with critical digital media and communication studies – especially the feminist, post-colonial and "global South" perspectives cited above, as well as the emerging scholarship on digital refusal which calls our attention to the need to denaturalize the embrace of digital technologies, and reduce their use (Kuntsman & Miyake, forthcoming; Hesselberth, 2018).

Finally, and more broadly, we propose that environmental communication as a field can take a stronger and more pro-active lead in abolishing digital solutionism, shifting towards what Gould (2016) described as "digital environmental media studies" – a perspective that, in its environmental thinking, is deeply accountable to the materiality of the digital itself. Informed by Comfort and Park's (2018) analysis of changes and agendas in environmental communication in respond to disciplinary growth as well as to environmental needs, we suggest that the field needs to:

(1) Bring its current agenda (such as climate change or energy demands) into the heart of digital media and communication studies – thus addressing the prevalence of the material blind spot in ICT and communication research.
(2) Expand its agenda, from primarily focusing on the communication aspect of environmental change to also including the environmental footprint of communication itself.

Notes

1. Stuermer et al. (2017) for example, note: "[w]e examined the benefits of sustainable digital artifacts without, however, focusing on any possible negative impacts of the use of technical infrastructure. […] We have neglected this aspect in our paper and, thus, implicitly assumed that, *compared to the benefits of higher accessibility,*

the negative impact on the environment of the large-scale use of hardware is marginal in view of the advantages of not having to recreate the same knowledge over and over. (p. 259, emphasis ours).

2. Digital solutionism, as Kuntsman and Miyake (forthcoming) note, can even be found even at the heart of digital refusal. In their work on "digital disengagement," Kuntsman and Miyake point to the paradox of a steady rise in digital tools (such as Apps or on-line initiatives to support those who wish to temporarily disconnect, or generally decrease their use of digital devices and communication platforms: one requires a digital solution in order to disconnect from the overwhelm of the digital.
3. Please see Appendix 3 (see supplementary material) for the numbered articles that constitute our corpus.
4. At the same time, Gale, Ascui, & Lovell [17] caution about potential misuses of those tools: "While open data platforms may democratize access to information, this always comes with a risk of co-optation by more powerful vested interests" (p. 77).
5. Furthermore, some of them specifically note that ICT is the way to reduce environmental damages of our current lifestyles, see for example Blewitt [38] emphasizes the central role smart integration of ICT can play in shaping a low carbon economy.
6. In that respect, the recent rapid rise of "Big Data" and its assumed transformative potential is particularly telling. We have not included "Big Data" in our search term, which explains the relatively small number of articles referencing it. A systematic examination of Big Data narratives in sustainability studies would be a very important follow up project.

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